EBAA IRON
Connections™
TECHNICAL DATA FOR THE WATER & WASTEWATER PROFESSIONAL
FT - 04

How does the Force Balanced FLEX-TEND® Product Work?

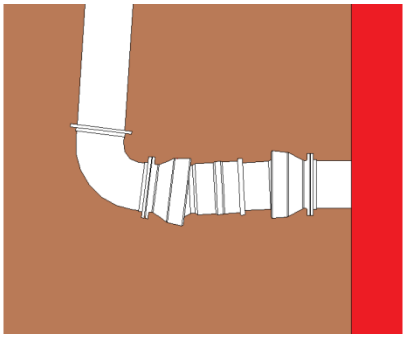
There are numerous configurations of flexible and expansion joints available to the design engineer. They include bellows joints, flexible hoses, bolted-mechanical couplings, and ball joints. In 1989 EBAA Iron, Inc. introduced the FLEX-TEND® joint (FT) flexible expansion joint product into the US market. Constructed of ductile iron, the product is comprised of two ball joints joined by an expansion joint. For the first time one product was available to protect pipelines and pipeline connections from differential movement resulting from seismic activity and soil expansion/contraction in areas of poor soil support, frost heave, and transitions from stable to unstable areas. Since its introduction, this product has provided years of pipeline protection from the external forces, with some of the most dramatic examples of successful protection provided by the FT being in areas that have been subjected to earthquakes.

While the total amount of expansion and contraction of the standard FT is controlled through integral, physical stops, one of the primary design considerations for the implementation of this product into a pipeline is the need to accommodate the hydraulic thrust force that develops when the unit is pressurized.

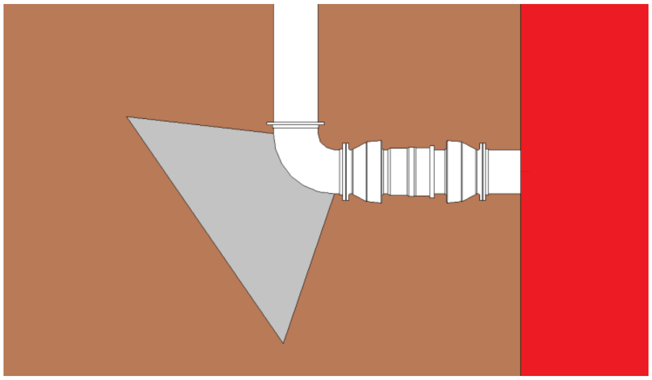
Now there is a new and improved design that incorporates a secondary hydraulic cylinder that counteracts the thrust force that develops at the pressurized, primary cylinder. That new product is the Force Balanced FLEX-TEND flexible expansion joint (FBFT). This dual cylinder design neutralizes that force while, at the same time, enabling the ability of the FBFT to expand or contract without restriction. The elimination of the hydraulic thrust force now allows the designer to incorporate flexibility into pipelines in a straight forward and cost-effective manner.

The Standard FLEX-TEND Joint

The thrust force often makes itself known where the FT is used in above ground or in underground situations where other fittings are in close proximity. Physical restraints must be used when the unit is installed above ground, at changes in direction, in long pipe runs where buckling can occur, or at connections to weak structures. At the same time the structural restraints must not restrict the ability of the FT to protect the pipeline from the damaging movement it was intended to accommodate. Depending on the configuration, this can be tricky. (See Connections Bulletins FT-03 and FT-05 for additional information on accommodating this thrust force.)



The expansion portion of the FT, the primary cylinder, acts like a conventional, single-acting hydraulic cylinder which is free to move within its physical limits. The following diagram illustrates how a FT, located between a bend (on the left) and a fixed structure such as a building (on the right) can affect the adjacent piping once the piping is pressurized and the thrust force comes to bear.



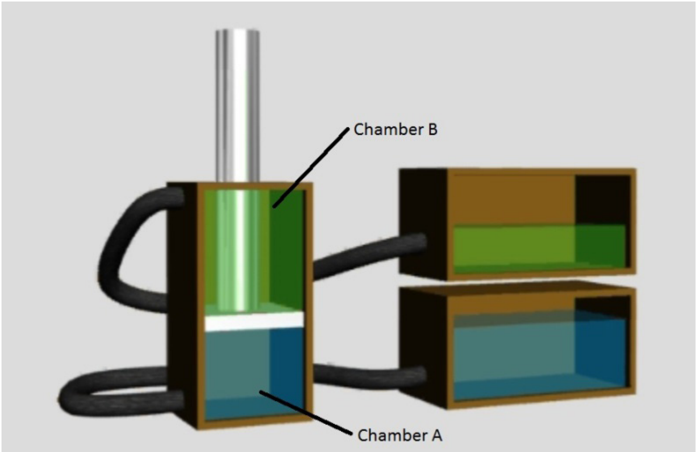
In order to accommodate the thrust force a physical restraint (in this example, a thrust block) must be incorporated into the design to keep the thrust force in check while allowing the FT to move freely when differential movement occurs.

The following photographs provide a real world example of this phenomenon in action. The photo on the left shows the FT connection after the water storage tank to which it was connected was filled with water. The head pressure from the filling of the tank was more than enough to develop a thrust force at the FT and cause the connecting 90-degree bend and vertical piping to deflect. A physical restraint (shown in the photograph on the right) was installed to constrain the thrust force once the head pressure was released and the piping realigned. This fix also allows the FT to accommodate differential movement between the fixed vertical piping and the tank structure during a seismic event or ground settlement without impeding the ability of the FT to move and protect the connection.

All of the concerns, considerations, difficulties, and complications discussed in the previous section are a direct result of the expansion forces that occur in a pressurized FT. These issues also require considerable design and construction time and resources.

The Force Balanced FLEX-TEND® Design

What was needed was some way to deal with the thrust force without compromising the overall design or the functionality of the FT. Consider the double-acting hydraulic cylinder (ENERPAC, 2013). A schematic of that cylinder is shown below.



When chamber A (the primary cylinder) is pressurized and chamber B (the secondary cylinder) is open, or vented, the plunger extends and exerts a force that is directed outwardly or in the up direction as shown in the schematic. Conversely, when chamber B is pressurized and chamber A is vented, the plunger retracts and moves inward or down.

Now consider a situation in which the hydraulic area of chamber A is <u>equal</u> to the hydraulic area of chamber B. If both chambers are subjected to pressure from the same hydraulic source the plunger will not move in either direction. The **force** in each direction is **balanced**. Assuming that the hydraulic source can accommodate an increase or a decrease in hydraulic volume, it is possible to physically move the plunger in either direction without assistance or resistance from the hydraulic pressure. Even if the hydraulic source pressure were to increase or decrease it is still possible to move the plunger.

This dual-acting cylinder scenario schematically describes the design of the FBFT. It has a primary cylinder (the same one that exists with the standard FT) but it also has a secondary cylinder. In operation, the hydraulic source is the fluid in the pipeline. Each cylinder has the same hydraulic area and is pressurized by the same source. As a result, the **force** from each cylinder is **balanced**.

Because the thrust force found in the standard FT is counteracted in the FBFT, there is no need to provide for structural accommodation of a thrust force through thrust blocks or other means. This frees the designer to protect the pipeline without the additional costs, structural requirements, or other limitations of the standard FT. It is important to note that adjacent pipe and fitting joints needs to be restrained to direct movement of the pipeline to the FBFT and/or to prevent thrust forces from the pipe and fitting joints from adversely affecting the pipeline.

Features and Configurations

The FBFT has many of the same features that are offered with the FT (see the FBFT product brochure and Connections FT-01 for more details). It is made of ductile iron conforming to the requirements of ASTM A536 and the applicable material requirements of ANSI/AWWA C153/A21.53. All of the seals are EPDM and are permanently lubricated so there is no required maintenance.

All interior or wetted surfaces and seal contact surfaces are coated with a minimum of 15 mils of fusion bonded epoxy. This coating complies with the material requirements of ANSI/AWWA C213. This coating extends to the exterior of the ball so that future motion of the ball joint is not impeded by corrosion. All exterior surfaces are coated with a minimum of 6 mils of fusion bonded epoxy conforming to the applicable requirements of ANSI/AWWA C116/A21.16

The standard end mechanical joint and flanged end connections are available. However, just as with the FT, other connections are available by special order. Finally, an 8 mil polyethylene sleeve is included for buried applications. The use of the polyethylene cover not only offers corrosion protection, but also reduces the soil's frictional resistance to movement.

Conclusion

Since its introduction, the FLEX-TEND product has proven to be a valuable design element that protects pipeline connections from damaging stresses that develop due to seismic action, soil movement, or thermal effects. The implementation of the FLEX-TEND joint in a design, however, is not as simple as installing a fitting. There are a number of considerations that must be evaluated and taken into consideration prior to finalizing a design and constructing the piping because of the expansion force that develops when it is pressurized. The new Force Balanced FLEX_TEND product incorporates an innovative design that eliminates that thrust force and frees the designer to utilize this product in ways that have been complicated before. Now, when the pipeline design engineer needs a option to protect the pipeline from differential movement, the Force Balanced FLEX_TEND product provides a simple, engineered solution.

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